Table 1. Components of the ethyl acetate extract of *Cyphostemma crotalaroides* roots

Compound No[a]	*Name*	*Amount present in extract (mg kg^{-1})*
1	resveratrol	85.14
2	ε-viniferine	90.4
3	*cis* ε-viniferine	[b]
4	pallidol	90.3
5	gnetin C	10.32
6	gnetin E	64.50
7	cyphostemmine A	34.82
8	cyphostemmine B	21.82
9	cyphostemmine C	11.6

[a] See Fig 1.
[b] Isolated from crude 3 in small amount.

3 RESULTS AND DISCUSSION

The root extract proved to have *trans*-resveratrol as a major constituent, together with eight other compounds (Compounds **1**–**9**, Fig 1) in quantities shown in Table 1. The NMR data were in good agreement with those in the literature for known compounds. The cyphostemmines A–C (Compounds **7**–**9**), although related to ampelopsin D (Compound **10**; Fig 1), have not been reported previously in the literature. They may be produced in the plant by a dimerisation process similar to that for the production of ampelopsin D.

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Aphid sex pheromones: manipulation of beneficial insects for aphid population control

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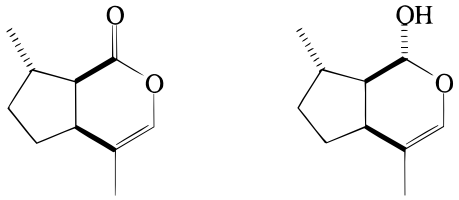
Keywords: aphid; sex pheromone; (4a*S*,7*S*,7a*R*)-nepetalactone; parasitoid; kairomone.

The sex pheromones for many aphid species, principally pests in the subfamily Aphidinae, have been identified as one or both of the cyclopentanoid monoterpenoids (4a*S*,7*S*,7a*R*)-nepetalactone (**I**) and (1*R*,4*aS*,7*S*,7a*R*)-nepetalactol (**II**).[1]



I **II**

Netpetalactone, **I**, can be extracted from catmint *Nepeta cataria* L. (Lamiaceae = Labiatae), and reduction of this affords nepetalactol **II**.[1] More recently, a synthetic route to **I** and **II** has been developed, starting from (*S*)-citronellol, which is commercially available in a range of enantiomeric purities, 99% (*S*), 95% (*S*), 98% (*R*) and racemic (50%). From this, a series of synthetic samples of aphid sex pheromone components and their enantiomers have been prepared to afford various (7*S*)- and (7*R*)-nepetalactones and nepetalactols.[2]

The field attractiveness of synthetic and plant-derived **I** and **II** to male aphids was investigated. Traps releasing a range of synthetic (7*S*)-**I** or (7*S*)-**II** captured significantly more of the target male aphids than did the traps releasing plant-derived **I** or **II**, with plant-derived impurities implicated as the agents reducing attractiveness of the latter.[3] The presence of the enantiomers (7*R*)-**I** or (7*R*)-**II** decreased catches, suggesting that, for aphids, reduced activity of sex pheromone components can be caused by trace compounds associated with reduced enantiomeric purity in terms of the (7*S*)-configuration.

Trap catches of male aphids also contained significant numbers of aphid parasitoids, indicating that these parasitoids use the aphid sex pheromone components as a host-location kairomone.[4] The attractiveness of synthetic and plant-derived **I** was compared for the generalist aphid parasitoid, *Praon volucre* (Haliday), and for the pea aphid parasitoid *Aphidius ervi* (Haliday) in a wind-tunnel bioassay. Females of both parasitoids made significantly more oriented upwind flights to both synthetic and plant-derived **I** than to the control treatments, but there

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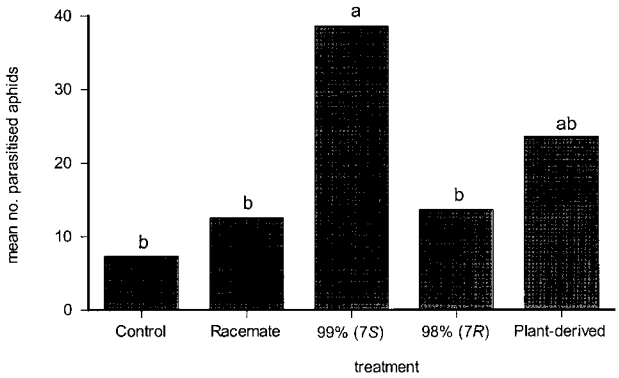

Figure 1. Parasitisation levels on aphid-invested plants baited with synthetic and plant-derived nepetalactone (**I**).

was no significant difference between the two nepetalactone treatments (Glinwood, RT, *et al.*, unpublished results).

The attractiveness of synthetic and plant-derived **I** to parasitoids was further examined in a semi-field experiment which employed aphid-infested trap plants. Analysis of the numbers of *P. volucre* mummies forming on the trap plants showed a significant effect of treatment ($P < 0.05$, 12 *df*, SED = 0.280, $F = 3.56$, Fig 1). Significantly more mummies formed on plants baited with 99% (7*S*)-**I** or plant-derived **I** than on unbaited control plants, whereas the number of mummies on plants baited with either (7*R*)-**I** or the 50% (7*S*)/(7*R*) racemate was not significantly greater than the control.

The manipulation of parasitoid behaviour was further examined by releasing plant-derived **I** in a winter-wheat field experiment. A comparison of pheromone-treated plots with control plots showed that parasitisation of aphids began earlier in the pheromone-treated plots. Thus it is demonstrated that the synthetic or plant-derived cyclopentanoid components of aphid sex pheromones have considerable potential for the manipulation of aphid parasitoids to enhance levels of parasitism and thereby induce aphid population control. The success of these experiments has led to the initiation of pilot systems for pheromone production from purified plant extracts, leading ultimately to the commercialisation of the aphid sex pheromones for the manipulation of beneficial insects.

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Plant secondary metabolites regulating behaviour of zoospores of the phytopathogenic fungus *Aphanomyces cochlioides*

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Abstract: A number of compounds isolated from various plant species were tested for their ability to affect the mobility of zoospores of the fungus *Aphanomyces cochlioides* which causes root rot in spinach (*Spinacia oleracea*). Compounds may act as attractants, repellents or stimulants of zoosphore movement or they may halt movement by causing the spore to clump and settle. Bioassay revealed compounds with these methods of action, as well as some which acted directly on the fungus.

Keywords: *Aphanomyces cochlioides*; zoospore attractant; repellent; stimulant; motility halting factors; spinach root rot

1 INTRODUCTION

Aphanomyces cochlioides Drechs is the fungus which causes spinach (*Spinacia oleracea*; Chenopodiaceae) root rot. Cochliophilin A (5-hydroxy-6,7-methylenedioxyflavone, Fig. 1, **1**) isolated from the roots of spinach, is a potent zoospore attractant. A second attractant, *N-trans*-feruloyl-4-*O*-methyldopamine (**2**) has been found in *Chenopodium album* L (Chenopodiaceae) which is also attacked by this pathogen, but which is not as susceptible as spinach. A third attractant, 5,4′-dihydroxy-3,3′-dimethoxy-6,7-methylendioxyflavone (**3**), has been isolated from the aerial parts of spinach. It is presumed that, prior to infection, the zoospores must be attracted to the roots of a compatible host plant which exude the host-specific signal substance(s). Alternatively, the roots of non-host plants may exude chemical signals indicating incompatibility with pathogens. This prompted a survey of plant metabolites which afforded unusual effects on the swimming behaviour of

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